The ILRS Technical Workshop 2009: SLR Tracking of GNSS Constellations

50 years of Satellite Geodesy & Geodynamics

The 2009 International Laser Ranging Service (ILRS) Technical Workshop addressed a very timely issue: the tracking of current and future Global Navigation Satellite Systems (GNSS) constellations with Satellite Laser Ranging (SLR). The idea behind this workshop was to bring together experts from the SLR and GNSS communities providing them with a forum to discuss all aspects of the theme, focusing primarily on the science benefits, while tackling also problems arising from the large number of GNSS clients and the finite resources available to ILRS. In the opening lecture of the workshop, Professor Emeritus of the National Technical University of Athens, George Veis, the person to whom the workshop was dedicated on the occasion of his 80th birthday and who is by most considered the father of satellite geodesy, offered an excellent historical review of space geodesy, from its inception to present, including all modern space techniques with many examples and some rare photographic records.

The workshop intended to survey the two communities on the likely gains in Global Geodetic Observing System (GGOS) science from SLR tracking of GNSS constellations. Amongst the objectives of the workshop were to present an overview of the two techniques with emphasis on their synergism, a review of GNSS and SLR constellations and their networks, and the current state of the art. Additionally, presentations demonstrated how the two space geodetic techniques are applied in geodynamics, POD, positioning, gravity mapping, etc. One of the most central objectives was to examine approaches to help accomplish the goals set by GGOS, investigating the various options available (e.g. higher repetition rates, optimal normal point formulation, interleaving tracking of targets, better sampling of orbits, allocating targets to sub-networks, etc.). One of the goals of the workshop was to select the appropriate information for the optimization of the network design and deployment of the appropriate space segment to meet the GGOS requirements. A significant part of the deliberations was devoted to the fundamental differences between geodetic cannonball type targets (LAGEOS) and the complicated GNSS spacecraft. The material presented at the workshop indicated that applications specifically enabled through the synergism of the two techniques would likely benefit the most, however, additional studies taking into account the discussed mode of operations are required in order to define this qualitatively.

The meeting stressed that there is great synergism between the two techniques and that these synergies should be fully exploited to the benefit of the larger community, in particular the communities of space geodesy and Earth science. What is now required is to understand the requirements of each of the GNSS constellations and then to optimize SLR and GNSS resources to maximize the benefit to all.

The combined list of benefits to both techniques, space geodesy, and to the broader community of users in general, can be summarized in the following:

- SLR tracking of the GNSS satellites allows to connect the ILRS/SLR and IGS/GNSS reference frames in space (using "space ties");
- Validation and calibration of the GNSS orbit quality, passing SLR tracking through GNSS-based orbits and by comparison of GNSS orbits to independently determined orbits from SLR tracking;
- Improvement of GNSS-based results by combining SLR and GNSS data at the observation level;
- Improvement in the determination of the SLR contribution to the terrestrial reference frame by including laser ranging to GNSS satellites along with that to lower satellites (e.g. LAGEOS);
- Improved scale contribution to International Terrestrial Reference Frame (ITRF) from improved GM estimates based on SLR tracking of GNSS satellites (and indirect improvement of lower orbits as well, e.g. for LAGEOS);
- Improving the orbits of LEO satellites with onboard sensors like radar and laser altimeters, sounders, SAR, InSAR, etc.

The presentations of the GNSS operators indicated that there is already a great effort on interoperability of these constellations for the benefit of society. It remains to be seen if these operators will rise to the occasion and we will see an equally enthusiastic harmonization of their relationship to the SLR community, signing up to the requirements and ensuring a uniform treatment for all GNSS constellations. This can only increase the benefits to all parties and keep the cost and effort of the SLR community as low as possible.
From the GNSS point of view, the most important requirements on SLR are:

- Continuous SLR tracking of all GNSS targets, or as network capacity permits, using optimized scenarios that ultimately rely on the combined use of the two techniques;
- GNSS operators should follow strictly the ILRS recommendations for laser reflector array (LRA) designs to meet network requirements for best data yield;
- The SLR community should document unambiguously and maintain a publicly accessible data base of all known system biases for the ILRS network, past and future, with clear documentation even for non-SLR users;
- Extensive and timely (even near real-time) support of GNSS constellations, especially during the initial deployment phase and their “in-orbit validation” phases for models, hardware, software, operations, etc.

From the ILRS point of view, important requirements are:

- All of the GNSS operators should adhere to the adopted ILRS standard for the laser reflector arrays (LRA), so that ILRS can assure uniform tracking capability throughout its network and at all times and conditions;

- An accurate calibration of all LRA designs prior to launch with a goal of a measurement of the vector to the center of gravity of the spacecraft to within a few millimeters (1-3 mm) and continuous monitoring of any changes while in orbit, due to fuel expenditure, attitude changes, etc. ;
- A precise description of the spacecraft attitude routine while in orbit and during periods of SLR tracking in particular;
- The ILRS must work with the separate GNSS constellation communities to develop a practical strategy to satisfy both the tracking requirements of the constellations and those for the development of the terrestrial reference frame;
- The ILRS should continue the simulation activity on GNSS satellites in order to quantify trade-offs among competing options

An overarching requirement is that the GNSS and SLR communities work together to facilitate communications so that planning can be done well in advance of any new GNSS deployments to exploit best the combination of techniques.

The success of the workshop is the result of the hard work of those who assembled and presented the various position papers, as well as those who contributed with supporting presentations and discussions. This workshop is only a first attempt to bring closer two of the IAG Services, ILRS and IGS, and it is hoped that it will be followed by similar events which will result in even closer collaboration between the two in the realm of GGOS. Finally, the overall success of the event is the result of the hard work of the local organizing committee and the support that we received from our sponsors. The workshop adopted unanimously a resolution thanking each and everyone who contributed to the success of the workshop.